Nuclear diffuseness as a degree of freedom: II. An improved approach*

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We use our standard self-consistent Thomas-Fermi model of nuclei to calculate the neutron and proton densities, from which we deduce the associated potential wells. We do this for the equilibrium densities as well as for the non-equilibrium densities with larger or smaller diffusenesses. This makes it possible to correlate the changes in the potential well diffusenesses with the energy cost in going away from the optimum values. These and other properties of the Thomas-Fermi potential wells are tabulated for nuclei with mass numbers $A = 20$ to $A = 340$ along the valley of stability, as well as for neutron-rich or neutron-deficient isotopes. The results are represented by polynominal fits that may be used in macroscopic-microscopic studies of the surface diffuseness degrees of freedom.

In [2] an estimate was made of the response of the nuclear energy to changes in the diffusenesses of the neutron and proton density distributions. The knowledge of this response is necessary for a generalization of the macroscopic-microscopic method of calculating nuclear masses (including the stability of superheavy nuclei), the generalization consisting of the addition of the surface-diffuseness degrees of freedom to the shape degrees of freedom specifying a nuclear configuration.

For a range of nuclei around beta stability it is possible to construct Thomas-Fermi predictions for the optimum Woods-Saxon parameters that minimize the macroscopic energy, in particular the optimum proton and neutron diffusenesses. It is also possible to estimate the energy cost in departing from these optima. By combining this with the response of the (Strutinsky) microscopic shell effects to diffuseness changes, it will be possible to evaluate the effect of including the new diffuseness degrees of freedom in a macroscopic-microscopic study of nuclear properties.

It remains to be seen whether this generalization will improve (or spoil!) the agreement with data (such as nuclear masses and single particle level orderings). It should be kept in mind, however, that this problem is not quite straightforward. First it would be too much to hope for that the semi-classical Thomas-Fermi predictions should lead at once to the absolutely best fit to sensitive quantal properties like level orderings. Second, other adjustable parameters are coupled to changes of the diffuseness, especially those describing the spin-orbit coupling. A re-adjustment of those parameters, as well as some fine tuning of the trends predicted by the Thomas-Fermi model, is certainly to be expected.

If it turns out that the new diffuseness degrees of freedom lead to a significantly better representation of known data, one will be in a position to give an improved estimate of the stability properties of superheavy elements and of other properties of exotic nuclei in general.

*Extracted from Ref. [1]

[1] W.D. Myers and W.J. Świątecki, Phys. Rev. **C60**, 054313 (1999).

[2] W.D. Myers and W.J. Świątecki, Phys. Rev. **C58**, 3368 (1998).